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OPERATION MANUAL
FOR
CONICAL SHELL PROGRAM

by

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INTRODUCTION

The material of this report is designed to supplement MASC Report No. 63-13. The theoretical aspects of the analyses or the numerical techniques used to find the stresses and displacements in conical shells covered in that report and will not be included here. It is the purpose of the report to present detailed instructions for the preparation of data for the computer program provided. It is assumed that the reader has no prior knowledge of Fortran. It is imperative that the instructions presented herein be followed implicitly. Failure to do so may result in incorrect or extremely inefficient operation of the program.

System Requirements

The program is designed for a high speed digital computer with 32 K core storage capacity and at least two auxilliary tape units in addition to input and output tapes. In order to provide for installation flexibility, the symbolic tape unit designations are controlled by fixed point variables defined in the main program and three subroutines (Input, RKI, Output). As prepared, the decks use Symbolic Input Tape No. 5 as the Input tape, Symbolic Output Tape No. 6 as the Output tape, and Symbolic Tapes Nos. 2 and 8 as scratch tapes. If the installation using this program has tape system requirements other than those specified, it is only necessary to introduce the proper tape identification numbers in the cards listed in the table below.

Tape Function	Tape Symbol	Cards
Input tape	NIN	MAI 0240 INP 0140 OUT 0110 RKI 0210
Output tape	NOUT	MAI 0250 INP 0150 OUT 0120 RKI 0220
Scratch tape	NDAT 2	MAI 0260
Scratch tape	NDAT 1	MAI 0270

General Operation of Program

The program accepts as input data, the values of all parameters pertaining to the geometry of the shell. (The exact specification is discussed in the section "Preparation of Data Cards"). In addition, certain control characters which determine input and output formats and range of summation of the Fourier series are accepted. The specification of loads is made by writing Fortran function sub-programs. (See "Specification of Loads".) Once the proper data have been presented to the computer, the program automatically calculates the displacements of the middle surface and the stresses at the inside, outside and middle surfaces.

These quantities are computed at a number of points on the generator and at a number of arbitrarily specified angles of longitude (with a maximum of 20 angles). If it is desired to sum the Fourier series, the program sums from an arbitrarily specified stopping index. The range of this summation is limited only by available machine time. At arbitrarily specified values of the Fourier index (maximum of 25) the stresses and displacements are printed out along with the sum of the series up to and including that term. It is important to note that the last value desired in the summation must be specified as one of the output indicies. Upon completion of the desired summation, the program automatically resets and accepts new data. These new data must pertain to the same loading conditions since the loads are not in general accepted as input data.

Automatic Segmenting Feature

As is discussed in the main report, in order to retain satisfactory accuracy in the integration process, it is necessary to break up the range of integration into a number of segments, these segments are further divided into integration intervals. In order to simplify the specification of a large percentage of problems, an automatic segmenting procedure has been incorporated in the program. When it is put in operation by a control character (See "Preparation of Data Cards") it is only necessary to specify the starting value of the independent variable and the final value. The program automatically selects segments and intervals that experience has proven appropriate for a large number of problems. It is recommended that this automatic feature be utilized whenever possible. No definitive statements as to specific applicability of this feature can be made; in general, however, unless the geometry is such that the "edge effects" are attenuated extremely rapidly, the automatic segmenting should work satisfactorily.

Physical Make-up of Program

The program consists of a main program, six subroutines, and five Fortran functions and input data cards. The source decks as submitted are identified by a deck name and sequence numbers in columns 73 - 80. The sequence numbers increase by ten from one card to the next.

The object decks are also identified by a deck name and sequence number in columns 73 - 80. The program is written in Fortran II and should be assembled with the appropriate system control cards.

Preparation of Data Cards For Conical Shell Program

Introduction

The input data is made up of 12 types of cards. Both format and order of input cards is important. The format for each type of card is illustrated below.

Type I (1 required)

This is an identification card. It may contain any message of up to 80 characters. The contents of this card will be exactly duplicated on the first page of output.

Type II (1 required)

Format (I4)

This card contains a single number specifing the number of terms of the Fourier series to be summed. No decimal point should be used. The number should be written with the units digit in column 4. This number must be 1 or greater.

Example (Type II)

_ _51_ _

This would cause the program to sum 51 terms of the Fourier expansion.

Type III (1 required)

Format (6 (I 2))

This card contains six two digit control numbers starting in Col. 1. These numbers are written without decimal points and blanks are treated as zeros. The specification and function of each of the six numbers is explained below. The six numbers are called I 1, I 2, ... I 6.

I 1 (Cols 1 & 2

I 1 must = 00, Input X in inches.

I 2 (Cols 3 & 4)

The physical boundary conditions at the beginning of integration are specified by this control number.

I 2 = 01, Clamped Boundary

I 2 = 02, Simply Supported Boundary

I 2 = 03, Free Boundary

I 3 (Cols. 5 & 6)

The physical boundary conditions at the end of the integration region.

I 3 = 01 , Clamped Boundary

I 3 = 02 , Simply Supported Boundary

I 3 = 03 , Free Boundary

I 4 (Cols. 7 & 8)

Automatic sequencing

I 4 = 00 , Automatic sequencing

I 4 = 01 , Manual sequencing

I 5 (Cols. 9 & 10)

Output Format of X .

I 5 = 01 , X measured as a fraction (Note: this format is useful for plotting.)

I 5 = 02 , X measured in inches

I 6 (Cols 11 & 12)

Stress resultants

I 6 = 00 , No stress resultants are printed.

I 6 = 01 , Stress resultants printed

Example (Type 3)

000301000100

This card provides for inside boundary free, outside boundary clamped, automatic sequencing, output as fraction, and no stress resultants.

Type IV (1 required)

Format (4 (1x; E14.8))

This card contains some of the geometrical and material properties of the shell.

Cols.	Quantity	Units
2 - 15	Young's Modulus	LB/IN^2
17 - 30	Poisson's Ratio	
32 - 45	Cone Half Angle	Degrees
47 - 60	Thickness of Shell	Inches

Example (Type IV)

_3.0_ _ _ _ _ _ _ _E_07_ _ _ _ _ _ _ _E_00_30._ _ _ _ _ _ _E_00

_0.25_ _ _ _ _ _ _ _ _ _ _ _

$E = 3 \times 10^7$ psi

$\nu = .3$

$\alpha = 30^{\circ}$

$h = .25$

Type V (1 required)

Format (1 x, E14.8, I 4)

This card contains the initial hydrostatic pressure in the shell (if pressurized) and the first value of the Fourier index to be used.

Cols	Quanitiy	Units
2 - 15	Initial pressure in shell	psi
16 - 19	Starting Fourier index, units digit in col. 19	

Example (Type V)

_0.25_ _ _ _ _ _ _ _E.03_ _ _ _ _ _ _ 3

Initial pressure = 250 psi

First term of expansion = 3

Type VI (1 required)

Format (2 (1x, E14.8))

This card contains the mass density and the circular frequency of vibration.

Cols	Quantity	Units
2 - 15	Mass density of shell material	$Slugs/in^3$
17 - 30	Frequency of vibration mode	Rad/sec

Example

_0.20___________E-01 _2.5_______E+02

Density = .02 $Slugs/in^3$ Vibration frequency = 250 rad/sec

Type VII (Two required)

Format (4 (1x, E14.8))

These two cards modify the boundary conditions. The first card refers to starting condition, and the second to final conditions. Depending on the values of I 2 & I 3 chosen the numbers read in on these cards represent non-zero boundary conditions. For example, if I 2 = 01, the 4 numbers on the first card represent non-zero values of U, V, W and Slope. Let the four numbers on a card be C1, C2, C3 and C4.

I 2 or I 3	Quantities represented by C's
01	C 1 = U
	C 2 = V
	C 3 = W
	C 4 = Slope
02	C 1 = U
	C 2 = V
	C 3 = W
	C 4 = Mxx
03	C 1 = Nxx
	C 2 = Mxx
	C 3 = Q_z
	C 4 = Q_θ

Example (Type VII)

Card VII - 1

Blank

Card VII - 2 (I 3 previously defined as 01)

_0.001_____E_00 (Rest of card blank)

This would represent a condition under which the outer boundary is given a displacement of .001 inches in the U direction, V = W = Slope = 0.

Type VIII - a (1 required)

The "a" designation indicates automatic segmenting in operation.

Format (2 (1X, E14.8))

This card contains the starting angle and the stopping angle for integration.

Cols	Quantity	Units
2 - 15	X - start	inches
17 - 30	X - end	inches

Example (Type VIII - a)

(I 1 = 01) & I 4 = 0

_0.1___________E___00__1.0________E_02

This represents a cone starting at X = 0.1 "and ending at X = 100".

Type VIII - m (1 required)

Manual sequencing

Format (I 3, 2X, E14.8)

This card contains the number of segments to be used and the starting value of x. Note, this start may not be specified as zero.

Cols.	Quantity	Units
1 - 3	Number of segments	
6 - 19	Start of integration	inches

Type IX - a None Used

Type IX - m (Number required equals the number of segments specified in card VIII - m).

Format (I 3, 2X, E14.8)

These cards contain the number of integration steps in this segment and the value of x at the end of this segment.

Cols.	Quantity	Units
1 - 3	Number of steps	
5 - 19	X at end of segment	inches

Example

Card IX - m - 5

_10_ _0.4_ _ _ _ _ _ _ _ _E_00

Card IX - m - 6

_20_ _ 0.45_ _ _ _ _ _ _ _E+ 00

For segment 5, there would be 10 steps ending at .4 inches. For segment 6, there would be 20 steps starting at .4 inches and ending at .45 inches.

Type X (1 required)

Format (I 3, IX , I 3)

This card contains the number of longitudinal angles desired in output; (cols. 1 - 3, units digit in col. 3, max. of 20 angles) and the number of different values of the fourier index for which output is desired. Important Note: This number must be at least 1. (Cols. 5 - 7 units digit in col. 7, max. of 25 output indicies.

Example

_ _ 5 _ 10

Five values of will be used for output, and output will be printed after calculation of 10 different values of Fourier index.

Type XI (Number required equals the number of angles specified on card IX)

Format (E 14.8)

This card contains in cols. 1 - 14, an angle (θ) in degrees for which output is desired.

Example

30. _ _ _ _ _ _ _ _ _ E _ 00

Output will be given for $\theta = 30^{\circ}$

Type XII (Number required equals the number of values of the Fourier index specified on card X)

Format (I 3)

This card contains the value of one of the Fourier indicies for which output is desired (Cols. 1 - 3, units digit in col. 3)

Important Note : It is required that one value of the output indicies must be the last term in the summation.

Example

014

Output will be presented after 1 4 terms of the series have been computed.

Specification of Loads

In order to provide flexibility in the specification of the loads acting on the shell, commensurate with the capabilities of the analysis and program, the specification of loads is made in terms of simply written Fortran functions. Five functions are required. The specify the three components of surface traction and two terms giving the temperature gradients in the shell. The names of the functions are as follows:

XX — The surface traction tangent to the generating curve and considered positive in the direction of increasing X.

YY — The surface traction tangent to the surface in the direction of a line of latitude considered positive in the direction of increasing θ .

ZZ — The surface traction normal to the surface, considered as positive outward.

TB — $TB = \frac{E\beta h}{(1-\nu)} T_n$

where T_n is the Fourier coefficient of the temperature.

TS — $TS = \frac{E\beta h^3}{12(1-\nu)} t_n$

In order to illustrate the method of preparing the Fortran functions an illustrative example is provided. For other examples, see the operation manual for spherical shells.

Example

A couple load from a circular pad normal to the surface. The maximum pressure, the pad radius and the location of the pad center line are accepted as input.

CIRCULAR PAD LOAD (COUPLE)

```
Statement
  No.
1       5 6 7
              FUNCTION ZZ (X, SN)
C             COUPLE LOAD, CIRCULAR PAD, CONICAL SHELL
              DIMENSION DUMMY (324)
              COMMON DUMMY, ALP
              NIN = 5
              NOUT = 6
              M = SN
              PI = 3.14159
              IF (A - 1234567.) 1, 2, 1
    1         READ INPUT TAPE NIN, 10, XCL, R, P
              WRITE OUTPUT TAPE NOUT, 11, XCL, R, P
              A = 1234567.
              Y2 = (R * R - (X - XCL) * * 2.)
              IF (Y2) 20, 20, 21
   21         W = 2. * (Y2 * * .50)
              IF (M) 4, 3, 4
    3         GO TO 5
    4         AN = 2. * SINF (SN * W + 0.5/(RAD) )/ (SN *PI)
              GO TO 9
   20         ZZ = 0
    9         RETURN
```

CIRCULAR PAD LOAD (COUPLE)

```
Statement
   No.
1      5 6 7

   10      FORMAT (3 ( 1 X, E 14.8 ) )
   11      FORMAT ( /21H CIRCULAR PAD LOAD ZZ/17H PAD CENTER LINE = E 14.6,
        1  20H INCHES, PAD RADIUS = E14.6, 30H INCHES, PAD MAXIMUM PRESSURE = E 14.
        2  6)
           END
```

Appendix

Use of Pad Load Functions

In order to use the pad load functions supplied with the program, the following rules must be obeyed. The input data for the pad loads must be assembled at the end of the regular input date. The following order of assembly must be used.

1) Data for XX pad load (if any)
2) Data for YY pad load (if any)
3) Data for ZZ pad load (if any)
4) Data for TB hot spot (if any)
5) Data for TS hot spot (if any)

It is recommended that if the pad load functions are used, the manual segmenting option should be employed. As many segments as feasible should be used.

The data for any one of the pad (or hot spot) loads is prepared in the following form.

I. Rectangular Pads

A) Symmetric Loads

Format (4 (lX, E14.8))

Cols.	Quantity	Units
2 - 15	Position along the generator of pad center line	inches
17 - 30	Pad length (in direction of generator)	inches
32 - 45	Pad width	inches
47 - 60	Pad average pressure	psi

B) Couple Load (1)

Format (4 (1X, E14.8))

Cols.	Quantity	Units
2 - 15	X coordinate of the pad center line	inches
17 - 30	Pad length	inches
32 - 45	Pad length	inches
47 - 60	Pad maximum pressure	psi

II. Circular Pads

A) Symmetric loads

Format (3 (1X, E14.8))

Cols.	Quantity	Units
2 - 15	X coordinate of the pad centerline	inches
17 - 30	Pad radius	inches
32 - 45	Average pad pressure	psi

B) Couple Loads (1)

Format (3 (1X, E14.8))

Cols	Quantity	Units
2 - 15	X coordinate of the pad center line	inches
17 - 30	Pad radius	inches
32 - 45	Pad maximum pressure	psi

---

(1) The load varies linearly with X with inward pressure at the "top" of the pad.